Synchrotron Radiation Instrumentation
Collaborative Access Team

SRI CAT NEWSLETTER

Vol. 3, No. 1 October 1996

From the desk of the Executive Director:

As I write this, the accelerator is just coming up for a six-week run, of which approximately four weeks are designated as User Beam. As one might expect, much of the initial beam time on the SRI CAT lines was allocated to the testing and performance evaluation of standard components and/or optical elements. The results of several such tests of critical components are summarized in the two main articles in this newsletter, namely an internally cooled, cryogenic silicon monochromator and x-ray beam position monitors. Still more components remain to be tested during this running period, most notably white beam mirrors on the Sector 2 bending magnet and insertion device lines. However, substantial chunks of beam time have recently been allocated to scientific programs, and the fraction of time going to science will certainly increase in the upcoming months.

The activities described above are good indicators that the SRI CAT is well on its way to completing the five beamlines (three insertion device lines and two bending magnet lines) that were outlined in the SRI CAT Final Design Report. In fact, we should have all of our critical optical components installed and most of the experimental stations on line by the end of calendar year 1996. Besides the hard work of the SRI CAT members, many of these activities could not have been achieved without substantial support from the Beamline Controls Group and the X-ray Optics Characterization, Fabrication and Metrology Laboratories.

On a completely different note, it is my pleasure to inform SRI CAT members that the X-ray Physics Group has received funding through the DOE's Scientific Facilities Initiative and will join the SRI CAT as Developers. Members of the X-ray Physics Group include: Roberto Colella and Steve Durbin (Purdue), Don Bilderback and Qun Shen (CHESS), Terry Jach (NIST), Al Thompson (LBNL), John Arthur (SSRL), and Simon Moss, (Univ. of Houston). The group's primary interest is to develop new x-ray-based techniques for investigating the microscopic properties of matter. Because I know all of the members personally, many of them for much of my career, it is particularly gratifying to welcome them all aboard, and I look forward to working with them in the future here at the APS.

The combination of new SRI CAT members and some very interesting experiments that have recently been performed on Sectors 1, 2, and 3 has prompted me to begin thinking about the next SRI CAT meeting. I am looking at the Jan/Feb 1997 time frame for that meeting and will let everyone know as soon a possible when a date has been selected. I hope those of you from out of town will be able to make it, and I invite you to stay in the User Residence Facility, which is currently scheduled to open soon after the start of the new calendar year. *D. M. Mills, Executive Director, SRI CAT*

Announcing

This is the last hard-copy newsletter you will receive. Beginning with our January issue, you will be able to find us at World-Wide Web site "http://www.aps.anl.gov/xfd/WWW/xfd/sri_cat/sri_cat_home.html", which will bring you to the SRI CAT Home Page. Here are a few instructions to help you open the SRI CAT Newsletters. First, you will need to download a version of Acrobat Reader, available free on the WWW (http://w3.aces.uiuc.edu/AIM/SCALE/tutorials/Acrobat/index.html). Once you've done that, simply run your Acrobat Reader program, and open the pdf file in which the newsletter has been saved. The document you should then be viewing will look exactly like the hard-copy version you would have received in the mail. With this electronic version you will be able save or print out any part of it.

If we have your e-mail address, you will also receive a copy by e-mail. If you are unsure if we have it, or if you have changed it, please let us know by contacting Laura Miller at "miller@aps.anl.gov" and she will add your name to the list.

Table of Contents

The Cryogenic Silicon Crystal Monochromator Stands Up to the Undulator on SRI CAT Beamline 1-ID

Introduction

The high-heat-load problem for double-crystal monochromators (DCM) on undulator beamlines at the Advanced Photon Source has, at least for the present, been solved! It was recognized early in the planning stages for third-generation, hard x-ray synchrotrons that the power emitted by insertion devices, undulators in particular, would probably pose the limiting factor on the quality (spectral brilliance and flux) of the monochromatic beam. In response, an impressive world-wide effort was mounted by researchers at many synchrotron facilities to find a solution. It is a credit to these laboratories that much of the research was complementary, with each devoting their effort to separate aspects and approaches contributing their own unique expertise to the problem. This article describes the results obtained during the May 1996 run at the APS using a cryogenically cooled, thin, Si(111)-oriented crystal installed in the Kohzu DCM on the Sector 1 undulator beamline, 1-ID.

This same crystal was tested on two previous occasions on a focused wiggler beamline at the European Synchrotron Radiation Facility [1,2]. The peak heat flux at the ESRF exceeded by a factor of two to three that of the APS undulator for closed-gap operation at 100 mA. However, the total power was only about one-fourth of that contained in the APS undulator central cone (2.5 x 2.5 mm^2). At the APS, rocking curves at various energies on and off the harmonics were measured for a range of undulator gaps from 11.1 to 21 mm at storage ring currents up to 100 mA. The maximum peak heat flux incident on the thin crystal was 1.5 W/mA/mm^2 with a measured power of 6.1 W/mA for a 2.0 H x 2.5 V mm^2 beam. The thermal broadening of the rocking curve was measured to be one arcsec or less at energies up to 30 keV from the third-order reflection.

Crystal Design

A photograph of the thin, cryogenically cooled Si crystal and its coolant distribution manifold is shown in Fig. 1. The thin element of the crystal was fabricated in a monolithic block of (111)-oriented Si by milling slots in the top and bottom faces, leaving a region approximately one-half mm thick. A third slot was milled in the downstream face to allow the transmitted beam to pass through. A maximum horizontal beam size of 2.5 mm can be accommodated, which includes essentially the entire central-cone radiation from the undulator. The downstream face of the crystal is visible, showing the slot that allows the transmitted x-ray beam to pass through. Also shown is the array of coolant channels on either side of the diffraction element. The seal between the Invar manifold and the Si crystal is made via In-coated metal C-rings. Sealing pressure is maintained by using Belleville® spring washers on the clamping screws. The mounted crystal assembly is supported on a kinematic plate that allows for unconstrained thermal expansion while preserving the absolute position of the thin diffraction element relative to the x-ray beam.

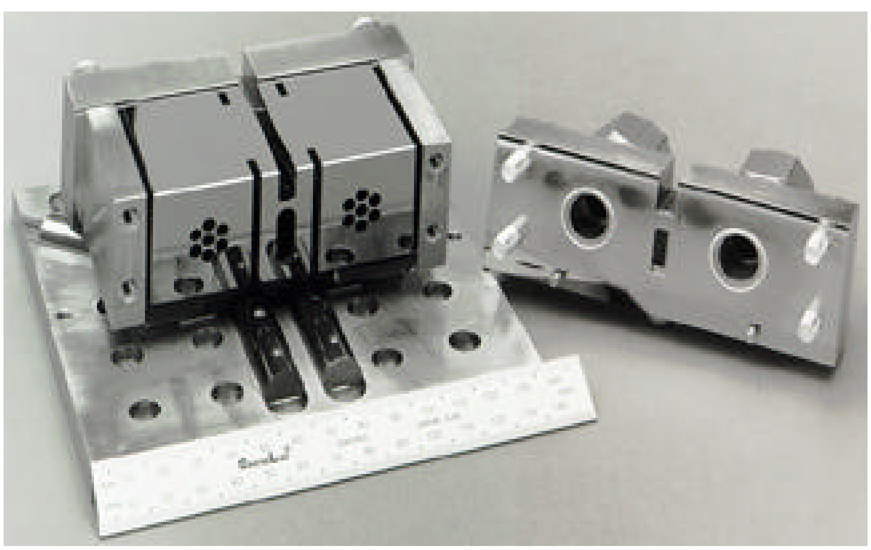


Fig. 1 Photograph of the cryogenically cooled, thin, Si crystal monochromator, coolant distribution manifold, and kinematic mounting plate. Visible is the downstream face of the crystal showing the exit slot for the transmitted beam and the array of cooling channels on either side of the diffraction slot.

Experimental Results

The crystal was installed and tested in the Kohzu monochromator [3]. A pumping system, assembled by Oxford Instruments-Accelerator Technology Group, supplied pressurized liquid nitrogen to the crystal. The beam emitted by the undulator passed through a temporary commissioning window positioned at 23.5 m from the source and consisting of 0.50 mm of graphite, 0.17 mm of CVD diamond, and 0.50 mm of Be. The fraction of the power absorbed in the commissioning window was about 12% for a 2.0 H x 2.5 V mm^2 beam at an undulator gap of 11.1 mm. Horizontal and vertical slits were located at 26.8 m, and the monochromator was at 28.5 m. A pair of ion chambers were placed at 34 m to monitor the diffracted beam intensity. An Al filter (0.09" thick) was placed between the ion chambers so that the first- and third-order reflections could be recorded simultaneously.

The performance of a thick part of the crystal was also investigated. The thick-crystal data were taken from the top surface of the monochromator crystal, laterally adjacent to the diffraction slot of the thin element. Obviously, the cooling geometry for the thick crystal data is not optimum because the heat flows predominantly to only one set of coolant channels, whereas the other set is thermally isolated by the diffraction slot. Rocking curves as a function of

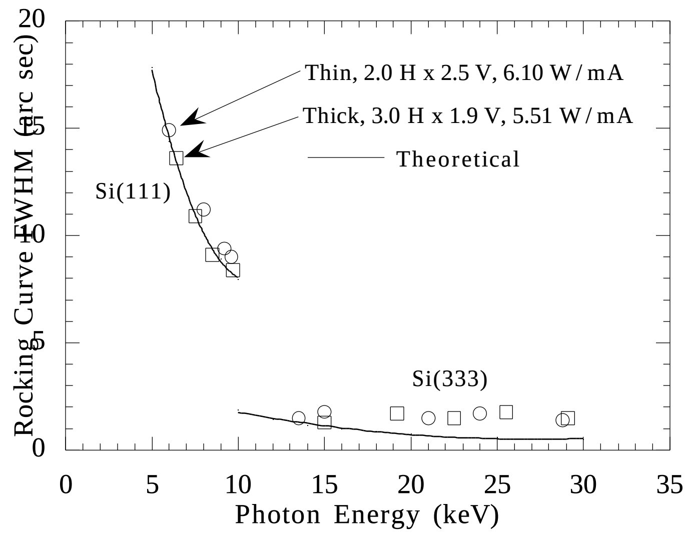


Fig. 2 First- and third-order rocking curve widths (FWHM) as a function of photon energy at a fixed undulator gap of 11.1 mm. The beam incident of the thin crystal measured 2.0 H x 2.5 V mm^2 with a power of 6.10 W/mA, and the beam on the thick part of the crystal measured 3.0 H x 1.9 V mm^2 with a power of 5.51 W/mA.

photon energy are shown in Fig. 2 for a fixed undulator gap of 11.1 mm, corresponding to a deflection parameter, K, of 2.57. This situation simulated far worse heat loads than would normally be encountered because the undulator gap was kept at 11.1 mm, corresponding to a first harmonic energy of 3.27 keV for all of the rocking curves, and was not opened to track the harmonic as the diffracted photon energy was increased, which would normally be the case. As the gap is opened, the power rapidly decreases. For example, for a first harmonic energy of 8 keV, corresponding to a gap of about 18.3 mm, the incident power and peak power density are only about 40 percent of that at a gap of 11.1 mm. Consequently, for typical operation in which the gap (i.e., harmonic) is matched to the diffracted photon energy, the monochromator should perform equally as well at much higher currents. The data for the thin crystal were collected with a 2.0 H x 2.5 V mm^2 beam with an incident measured power of 6.10 W/mA, and the beam size for the thick-crystal data was 3.0 H x 1.9 V mm^2 with a power of 5.51 W/mA. The storage ring current ranged from 61 to 96 mA for the thin-crystal data and from 89 to 95 mA for the thick-crystal data. A more detailed presentation of the results are given in Ref. 4.

Conclusions

The thin, cryogenically cooled monochromator crystal has been tested under the worst-case conditions with the APS undulator and has exhibited sub-arcsec thermal strain. Both thin and thick parts of the crystal were tested and performed about equally well. The thick crystal performed much better than our expectations, and, due primarily to its lower mechanical strain, it actually performed better than the thin crystal.

An important benefit of the thin crystal is that it absorbs only a portion of the incident beam power. About 50 percent of the power was absorbed from a 2.5-mm-square beam at an undulator gap of 11.5 mm and a Bragg angle of 19.24°. Future tests include evaluating just how thin the diffraction element can be made and still perform acceptably. It will be very important to reduce the absorbed power to a minimum, especially as the machine current is raised above 100 mA. The accelerator has already been tested up to 165 mA for a short period during the last running period. A nitrogen gas reliquefier with a cooling capacity of 360 W at 77 K will be installed on Sector 1 before the end of the year. This reliquefier will take the spent gas from the pumping system heat exchanger, liquefy it, and return it to the pump, thereby, making the cooling system a complete closed loop. This will eliminate the need for frequent supply dewar changes and decrease operator supervision of the cooling system. The cryogenically cooled monochromator and liquid nitrogen pumping system have been successfully tested and commissioned over the last several running periods on Beamline1-ID and have already provided the highest quality monochromatic beam used for several scientific experiments.

Acknowledgments

I wish to thank all of my colleagues in the high-heat-load working group and members of the SRI CAT Sector 1, in particular, Dr. Dennis Mills, Dr. Wah-Keat Lee, Dr. Patricia Fernandez, Dr. Tim Graber, Dr. Dean Haeffner, Mark Keefe, Bill McHargue, and Dale Ferguson for their assistance in making these experiments a great success. I also want to express my gratitude to Dr. Szczesny Krasnicky for his assistance in preparing and characterizing the monochromator crystal. *C. S. Rogers, Advanced Photon Source*

References

1. C. S. Rogers, D. M. Mills, W.-K. Lee, G. S. Knapp, J. Holmberg, A. Freund, M. Wulff, M. Rossat, M. Hanfland, and H. Yamaoka, "Performance of a liquid-nitrogen-cooled, thin silicon crystal monochromator on a high-power, focused wiggler synchrotron," *Rev. Sci. Instrum.*, **66(6)**, 3494 (1995).
2. C. S. Rogers, D. M. Mills, P. B. Fernandez, G. S. Knapp, M. Wulff, M. Hanfland, M. Rossat, A. Freund, G. Marot, J. Holmberg, and H. Yamaoka, "Further tests on liquid-nitrogen-cooled, thin silicon-crystal monochromators using a focused wiggler synchrotron beam," presented at the 8th National Synchrotron Radiation Instrumentation Conf., Argonne, IL, Oct. 1995, and published in *Rev. Sci. Instrum.*, **67(9)** (1996).
3. SRI-CAT Newsletter, Vol. 1, No. 3, Jan. 1995.
4. C. S. Rogers, D. M. Mills, W. -K. Lee, P. B. Fernandez, and T. Graber, "Experimental results with cryogenically cooled, thin, silicon crystal x-ray monochromators on high-heat-flux beamlines," presented at SPIE, Intl. Sym. on Opt. Sci., Engr. and Instrum., *High Heat Flux Engineering III*, Denver, CO, Aug., 1996.

Progress of the APS High Heat Load X-ray Beam Position Monitor Development

Introduction

A third-generation synchrotron radiation source, such as the 7-GeV Advanced Photon Source, generates high brilliance and intense synchrotron radiation from its insertion devices (IDs). There are many challenging tasks in the design of the ID beamline instrumentation that relate to high-heat-load and high-heat-flux problems. One such component is the X-ray beam position monitor (XBPM) for the ID front ends and beamlines. The design requirements for APS front-end X-ray beam position monitors (XBPM) are such that they must withstand the high thermal load (up to 600 Watts / mm^2) and be able to achieve submicron spatial resolution while maintaining their stability.

At the APS, each beamline front end has two XBPMs to monitor the X-ray beam position in both the vertical and horizontal directions. The XBPMs measure photoelectrons generated by pairs of sense blades and deduce the beam position by comparison of the relative signals from the blades. As shown in Figure 1, both the first and second XBPMs are located upstream of the 2nd photon shutter (user photon shutter) so that they are functional whether the user shutter is open or closed [1]. The major advantage of the XBPM is its high positioning sensitivity. Besides that, compared to the particle beam position monitors in the storage ring, the front end XBPMs have much higher sensitivity to the X-ray beam angular motion simply because they are located far away from the source.

Additional design challenges for a conventional photoemission-type XBPM are the bending magnet contamination of the signal and the sensitivity of the XBPM to the ID gap variations. Work at other synchrotron radiation laboratories has shown that contamination signals caused by the bending magnet (BM) emitted radiation become a major problem [2]. These problems are exacerbated for the XBPM when the IDs operate with different magnet gaps, because the percentage of the contamination varies.

There are several novel design features of the APS ID XBPMs that give better performance:

- Optimized geometric configuration of the monitor's sense blades.
- Smart XBPM system with an intelligent digital signal processor that provides a self-calibration function.
- Transmitting XBPM with prefiltering in the commissioning windows for the beamline front ends.

In this write-up, we briefly present the recent progress on the XBPM development for the APS ID front ends.

The Front End XBPM Structural Design

Since 1991, a number of the APS high-heat-load XBPM prototypes using CVD diamond as the blade material were tested successfully at CHESS and NSLS. Both analytical and experimental results proved that CVD diamond is a good choice for the APS high-heat-load XBPM blade material because of its superior thermophysical properties, such as high thermal conductivity, low thermal expansion coefficient, good mechanical strength, and stiffness under the heat load. Submicron position sensitivity was also demonstrated by the APS XBPM prototype using CVD diamond blades during CHESS and NSLS tests [3].

Figure 2 shows the structure of the first XBPM (upstream) main assembly on the APS undulator beamline front end. In this design, four 150-µm-thick CVD diamond blades (1) were coated with 1 µm of gold. The blades are mounted vertically in pairs on the monitor body (2), which is made of oxygen-free copper (OFHC) and is cooled by a water cooling base (3) from the bottom. The vacuum chamber (4) and the cool-

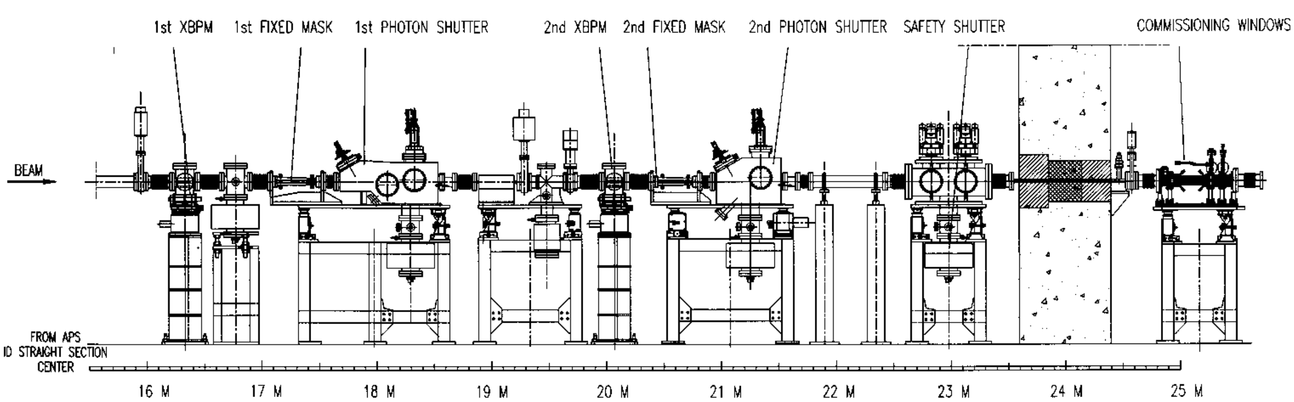


Fig. 1. Schematic of the APS undulator beamline front end.

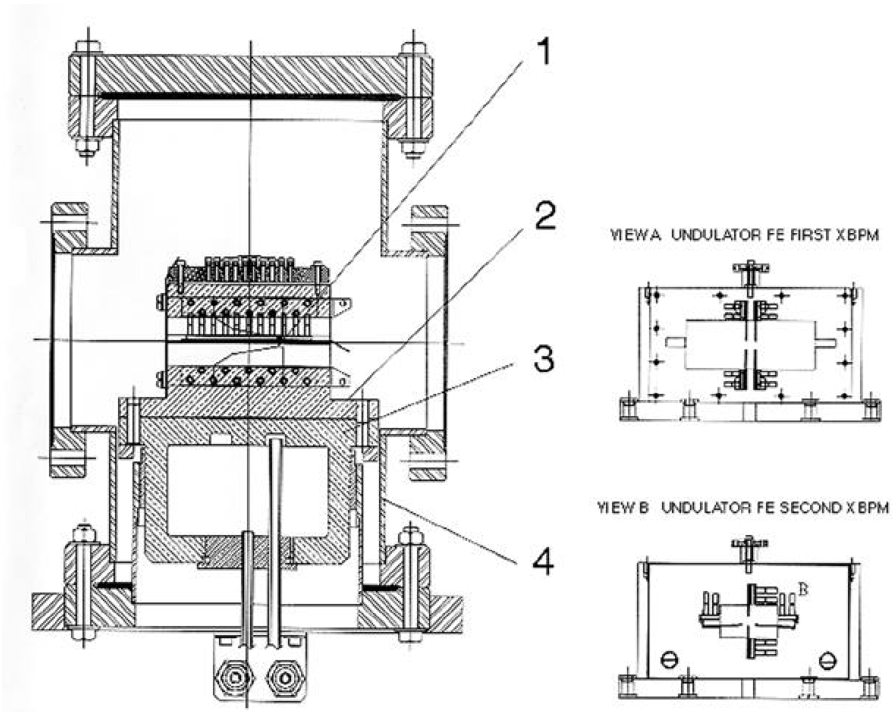


Fig. 2. Structure of the XBPM main assembly for the APS undulator beamline front end, (1) CVD diamond blades, (2) monitor body, (3) water cooling base, (4) vacuum chamber. (View A: first XBPM monitor body, view B: second XBPM monitor body).

ing base are designed for ultrahigh-vacuum (UHV) conditions.

To eliminate blade shadowing problems, the second XBPM (downstream) has a different blade placement configuration. As shown in Figure 2, view B, the second XBPM has one pair of vertical blades, and one pair of tilted horizontal blades. This configuration reduces signal contamination from the BM radiation.

The XBPM monitor has the capability to have a bias voltage applied. However, the test results show that a zero bias is acceptable and has the advantage of reducing the thermal resistance caused by the bias insulator. The geometrical configuration of the APS XBPM provides a low-noise environment for photoelectron current output. At the first APS X-ray test on March 26, 1995, the XBPM was sensitive enough to read out the photoemission signal (about 0.6 nA) from a BM source with only 24 µA of electron beam current in the APS storage ring.

Stability of the XBPM Supporting Stages

As shown in Figure 3, the XBPM main assembly (1) is supported by a precision supporting stage (2), which is mounted on top of a mounting post (3). The post is made of steel filled with sand and thermally insulated on the outside by ceramic cloth. This post design is very stable against short-term temperature fluctuations.

The XBPM stage assembly consists of stepping-motor-driven vertical, horizontal, and rotational stages. Test measurements using a Laser Doppler Displacement Meter (LDDM) proved that the vertical stage attained a resolution of <0.2 µm with 1 µm repeatability under a 200 lb load [4]. Preliminary *in-situ* vibration tests show that the XBPM main assembly undergoes less than 0.1-µm rms vibrational displacements with the cooling water on.

Smart XBPM System (SBPM)

The optimized geometric design of the blades helped to reduce the effect of BM contamination. On the first XBPM on the APS 1-ID front end, the BM contamination has been determined to be about 10% of the signal from the 2.4 m undulator A with a 15.8 mm magnet gap. However, the contamination level is much higher when the undulator gap is larger. The regular XBPM calibration process can only provide signal

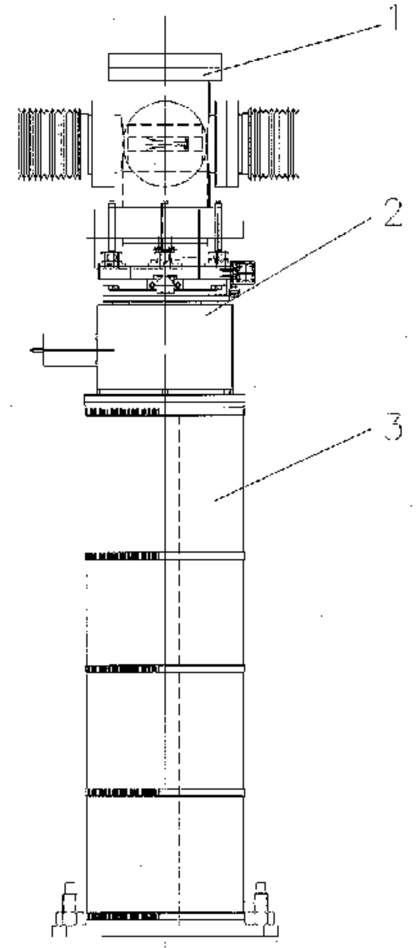


Fig. 3. Front end XBPM with supporting stages, (1) XBPM main assembly, (2) precision supporting stages (3) mounting post.

correction for one set of conditions. During normal operations, the insertion devices function at varying storage ring currents, particle orbits, and a variety of ID gaps. In addition, because of small imperfections in the ID magnetic field distribution, each ID and its location on the storage ring has its own “personality”.

To offset the XBPM sensitivity to such operational variables, a newer XBPM system has been designed and a prototype built and tested for the APS. This new XBPM system has an intelligent signal processor, which provides a self-calibration function to serve as a noise and contamination signal rejector to improve the system sensitivity and reliability [5].

The new APS XBPM system configuration is depicted in Figure 4. It includes:

1. a pair of photoelectron emission-style beam position monitors using CVD diamond blades for undulator beamline front ends.
2. a set of photoelectron current preamplifiers.
3. a preamplifier auto-ranging controller and digitizer [6].
4. a digital signal processor (DSP) with EEPROM data base and ID source setup input interface for normalization [7].
5. a system controller with motor driver and encoder interface for XBPM calibration processes.

Known as the so-called smart photon beam position monitor system (SBPM), the new system has a built-in EEPROM memory that is large enough to “remember” a complete calibration database covering all of the possible operating conditions. During the calibration mode, the monitor system controller initializes a series of automatic scan motions for the XBPM with different ID set-up information, and records them into the EEPROM database array. With the XBPM operating, the system corrects the normalized output according to the ID setup information and the calibration database. As a result, with this novel system, the XBPM is always calibrated.

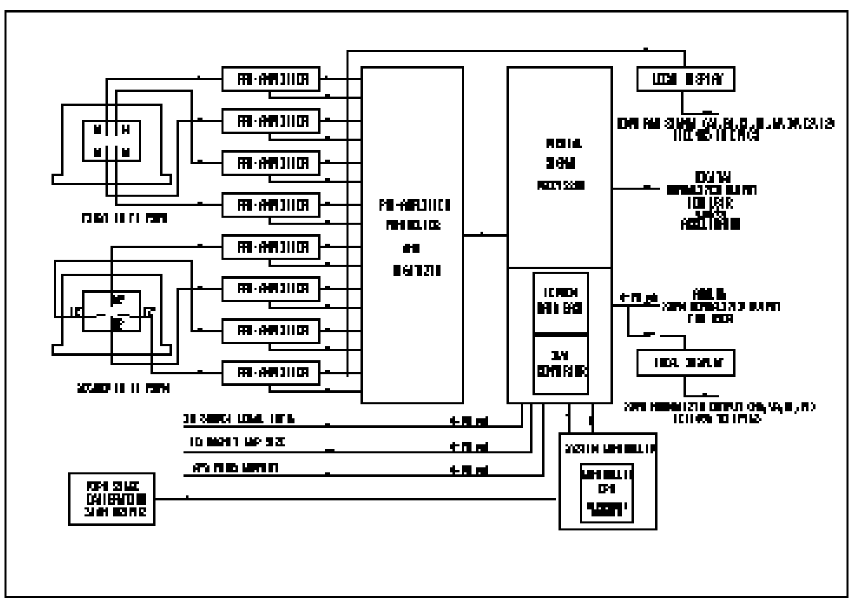
The heart of the smart system is a TMS320c40 digital signal processor from Texas Instruments Inc. [8]. This floating-point processor is designed specifically for digital parallel processing and real-time embedded applications. The key features of the TMS320c40 device, especially those used in the SBPM system, are: a high-performance DSP CPU with 40-ns instruction cycle times; a 40/32bit single-cycle floating-point/integer multiplier for high performance in computationally intensive algorithms; a six-channel DMA co-processor for concurrent I/O and CPU operation; six communication ports for high-speed intercommunication; 512 byte on-chip program cache and 8 kbytes on-chip dual-access/single-cycle RAM; and two identical external data and address buses supporting a shared high data-rate memory system.

In operation, the DSP gets the XBPM signal data from the preamplifier/digitizer through one of the communication ports and groups them into an input buffer array. Then, the DSP calculates the data under the control of a signal normalization program that uses the external EEPROM database for reference. After a step-by-step approaching process, the final beam position data (a pair for the beam positions at the first XBPM location and a pair for the beam angular displacement) are transmitted to a signal output buffer. There are two types of output data format available for users: a 24-bit digital parallel output and a 4-20 mA current loop for analog output. Both the digital and analog outputs contain the final beam position signal with a DC to 50 Hz or a DC to 300 Hz bandwidth (depending on the type of microprocessor to be used in the preamplifier controller).

Transmitting XBPM for the Front-End Commissioning Windows (TBPM)

Fine tuning of the storage ring and/or final adjustment of the front-end components is on-going during the beamline and front-end commissioning activities. Based on measurements of the beam position in two locations in an experimental station, and on the calibration scan data from the front end X-ray BPMs, a new "zero" position is set after the synchrotron radiation beam commissioning.

We have also designed a transmitting x-ray beam position monitor (TBPM) for the APS commissioning window system that uses a 25.4-mm diameter CVD diamond



Fig, 4. Schematic of the APS ID front-end smart XBPM system.

filter mounted on the downstream side of the fixed mask preceding the window [9]. The basic concept of the TBPM is to mount the monitor blade perpendicular to the synchrotron radiation beam and to design the blade and its low-Z metal-coating thickness in such a way that most of the X-ray beam is transmitted through the blade (just like a filter or window). In this design, the 160-µm-thick CVD-diamond disk is coated with four electronically isolated aluminum quadrant patterns. The thickness of the aluminum coating is about 0.2 µm. The photoelectron emission signal is collected by a terminal interface disk, which is made from thin alumina and is coated with silver. This design concept provides the possibility of integrating the filter with TBPM functions. The beam position information from the TBPM in the commissioning window is very valuable to the front-end commissioning and for initial calibration of the smart XBPM system.

Conclusion

Three prototype smart XBPM systems have been manufactured. Preliminary tests began in August 1996. In the initial stage, the smart XBPM system calibration is operated by a portable computer. Based on the experience from the prototype operation, we will determine the time duration of the calibration period and optimize the database structure. Automatic calibration is necessary if the particle beam orbit changes frequently. If needed, the beam position at the neighboring bending magnet front end may also be used as another database reference input.

A novel version of the APS high heat load XBPM, based on a CVD diamond *photoconductive* detector was tested at an ESRF undulator beamline in February 1996 [10]. This new position sensitive photoconductive detector (PSPCD) seems to have even less sensitivity to the BM radiation contamination. More tests of the PSPCD are underway. *D. Shu, J. Barraza, M. Ramanathan, and T. Kuzay, Advanced Photon Source*

References

1. D. Shu and T. M. Kuzay, *Nucl. Instr. and Meth.* **A347** (1994) 584.
2. T. Warwick et al. *Rev. Sci. Instrum.* **66(2**) 1995.
3. D. Shu, B. Rodricks, J. Barraza, T. Sanchez and T. M. Kuzay, *Nucl. Instr. and Meth.* **A319** (1992) 56.
4. T. Kuzay, **ANL/APS TB-5**, 1993.
5. D. Shu and T. M. Kuzay, "Smart X-ray Beam Position Monitor System for the Advanced Photon Source", *Rev. Sci. Instrum.* **67** (1996) CD ROM.
6. F. Meng, M. S. thesis, Illinois Institute of Technology, May 1995.
7. X. Wu, M. S. report, Illinois Institute of Technology, May 1996.
8. TMS320c4x User's Guide, Texas Instruments Inc. (1993).
9. D. Shu and T. M. Kuzay, "Design of the Commissioning filter/Mask/Window Assembly for Undulator Beamline Front Ends at the Advanced Photon Source," *Rev. Sci. Instrum.* **67** (1996) CD ROM.
10. D. Shu, T. M. Kuzay, J. Barraza, G. Naylor, and P. Elleaume, to be published.

Synchrotron Radiation Instrumentation Collaborative Access Team
Argonne National Laboratory
9700 South Cass Avenue
Argonne IL 60439

Executive Director
Dennis M. Mills

Director
Efim Gluskin

Associate Director
Deming Shu

SRI CAT Secretary
Laura Miller
Phone: 630-252-0160
Fax: 630-252-0161
e-mail: miller@aps.anl.gov

Newsletter Coeditors
Albert T. Macrander
Ian McNulty

Address additions, changes and deletions are welcome. Forward them to the SRI CAT Secretary.

Next Issue - January 1997

Publications

Macrander, A. T., P. A. Montano, D. L. Price, V. I. Kushnir, R. C. Blasdell, C. C. Kao, and B. R. Cooper, "Inelastic X-ray Scattering from TiC and Ti Single Crystal," *Phys. Rev. B* **54** (1996) 305-312

Sözen, M. and T. M. Kuzay, "Enhanced Heat Transfer in Round Tubes with Porous Insert," *Int. J. Heat and Fluid Flow* **17** (1996) 124-129

CD-ROM Publications

The proceedings of the 1995 National Conference on Synchrotron Radiation Instrumentation, held at the APS in October 1995, are now available on a special CD-ROM edition, *Rev. Sci. Instrum.* **67(9)**, (1996). Unfortunately, due to space limitations we cannot list here all of the papers by SRI CAT members, however, we encourage you to browse through the many interesting articles on this information-packed CD-ROM.

Who's New

Sateesh Bajikar recently joined XFD-ID as a post-doc. He completed his Ph.D. in materials science at the University of Wisconsin–Madison. At U.W. he worked on a wide range of microdevices, micromachining, and materials analysis techniques, including vacuum microelectronics, micro-optomechanical devices, LIGA, x-ray optical elements, and atom probes. His primary activity at the APS will be helping to establish microfabrication processes that will be used at the APS for micromachining using deep x-ray lithography.

Francesco De Carlo has joined the SRI CAT as a postdoc working on 2-BM. Francesco received his Ph.D. in electronic engineering from the University of Trieste, Italy with a thesis on a star identification, pointing, and tracking system for an attached shuttle payload instrument, as well as on silicon mircomachining, a flow sensor for aerospace application at the University of Twente, The Netherlands. In 1995-96 he was a visiting scientist at the University of Bonn and the Institute of Micromechanics of the Forschungszentrum Karlsruhe, Germany, working with LIGA for fabrication of micro-mechanical sensors. He will be working on LIGA technology and beamline experimental control at APS.

Chitra Venkataraman joined the X-ray Optics Group as a postdoc on July 15. Chitra received her Ph.D. in Physics from University of Illinois in Urbana-Champain. Here at the APS, she will be contributing towards the hard X-ray polarization effort working with George Srajer on magnetic Compton scattering experiments.

Parlapalli V. Satyam is a postdoc working on the x-ray heterodyne correlation spectroscopy project with Yiping Feng, Wenbing Yun, Zhonghou Cai and Sunny Sinha. He comes to XFD from the Institute of Physics, Bhubaneswar, India where he did his Ph. D. work with Prof. Bhupen Dev on x-ray standing wave and ion-scattering studies of metal-semiconductor interfaces and epitaxial layers.